

CHEMISTRY AS APPLIED TO CONSTRUCTION.

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CARBONIC acid, as it exists in natural quantity in the atmosphere, is absolutely essential to the welfare of the animal and vegetable creation, but as produced in undue quantity by the combustion of ordinary sources of heat and light, if it have not ready egress, acts as a narcotic poison upon man and animals, and as a poison to most tribes of the vegetable kingdom.

The chemist can prove that six parts by weight of carbon, when perfectly burned, produce twenty-two parts by weight of carbonic acid; hence the extreme danger of burning common charcoal in a brazier to warm or dry an apartment, unless there be a good ventilation, for the whole of its atmosphere will soon become impregnated with the mephitic vapour, and a person entering would be rendered insensible.

It is commonly supposed that the carbonic acid resulting from burning charcoal in a brazier remains as a heavy stratum of vapour upon the floor of an apartment as it does upon the floor of the "grotto del cane," and that no danger is to be apprehended in entering the apartment if a person stand upright, but this notion is seriously erroneous, as the chemist can immediately prove.

It is perfectly true that carbonic acid, however it may be produced or evolved, is heavier than air, and will fall or subside through air when it is of the same temperature as the air, or when it is of a lower temperature than the air, and such is the case in the "grotto del cane;" but as carbonic acid is formed during the combustion of charcoal, it is materially lighter than air, because it is of an exceedingly high temperature, or, in other words, rarified by the heat; and, accordingly, it ascends in virtue of this thermal levity, and bleeds uniformly with the air of the apartment, whilst another curious action is simultaneously ensuing, viz., the charcoal, in order to burn and to continue burning, must have oxygen, it takes this from the air to form carbonic acid, but leaves the nitrogen, which is equally mephitic, so that, in the course of a very short time, if no egress be permitted for these substances so inimical to life, the entire volume of the air becomes thoroughly vitiated, and a person entering the apartment would be suffocated.

Another fact in connection with the point in question demands attention. Suppose (as is frequently the case when work is to be hurried) that a brazier containing a bushel of burning charcoal be placed in the middle of a room, and then all the doors and windows be closed "that the heat may dry the plaster walls," why, in the course of an hour or two, when the workman thinks "the charcoal has burnt out," or the "brazier wants filling," he opens the doors "to let the foul air escape," and after a few minutes he enters, and finds to his surprise that "the fire is quite out, though there is plenty of charcoal left in the brazier." He is at a loss to account for this, but the reason is extremely simple; the combustion or burning of the charcoal ceases when it has withdrawn the greater portion of oxygen from the air to form carbonic acid, and has liberated nitrogen, for charcoal can neither burn in the compound result of its own combustion, nor in the elementary nitrogen, for these two extraordinary substances are as fatal to flame as they are to life.

In order to effect the entire combustion of the charcoal used in drying the walls of an apartment, the top sash of a window should be opened a few inches, and the door left "ajar" to a similar extent; or if there be two windows, the top sash of one, and the bottom sash of the other, should be thus opened, and the door closed; and then, in the first case, the heated carbonic acid and nitrogen would escape by the window, whilst fresh air would enter by the door, to supply the fuel; and in the second case, the escape would still be by the top of the one window, whilst the entrance of the fresh air would be at the bottom of the other. A ventilation thus established would have the additional advantage of carrying off the steam produced from the damp walls, instead of its "sweltering" them, as when the apartment is confined. And if several shallow pans, filled with "cream of lime," be placed upon the floor, and at different heights above it, much

of the carbonic acid would be withdrawn to form carbonate of lime; thus an additional call would be made for the entrance of fresh air from without.

Let us now examine the sources from whence the great supplies of quicklime are derived. Carbonate of lime is presented by nature in vast abundance, and is familiarly known as marble, limestone, and chalk; in these substances the carbonic acid and the lime are held together with a certain degree of chemical affinity, and under all ordinary circumstances they manifest no tendency to separate from each other, but this affinity can be readily overcome by several chemical agents.

Thus, if a fragment of marble, limestone, or chalk, be placed in a clear glowing fire, and there allowed to remain thoroughly red hot for about an hour, upon removal and cooling, it will be found to possess all the characters of "quicklime," because the heat of the fire has caused repulsion to ensue between the carbonic acid and the lime, the former being volatile, escaping with the products of the combustion of the fuel, whilst the latter being fixed remains behind. Upon this fact is founded the ancient and well-known practice of "lime-burning," but all varieties of native carbonate of lime are not equally adapted for "burning into lime" for the purposes of the architect and the builder; thus if pure white marble be heated, its decomposition will be effected, but the resulting lime will appear in a sandy or pulverulent form, due to the crystalline particles of the marble being violently thrust apart, as the carbonic acid escapes, and this sandy or arenaceous form of lime does not admit of ready separation from the ashes of the fuel employed in the furnace or kiln, in which the "lime burning" or calcination is conducted.

Pure white marble, or *primitive marble*, as it is called by geologists, from the fact of its never containing *organic remains*, is rarely used as a source of quicklime, but the common limestones, called *secondary marbles*, from their containing such remains in abundance, are mostly selected; but even then, an examination upon a small scale should be conducted to ascertain that such varieties neither crumble into dust nor fuse by the heat of calcination, for some limestones containing *silica* or the pure matter of *flint*, will readily fuse into a kind of "slag," on account of chemical affinity exerted between the silica and the lime, as noticed at an early period of this inquiry regarding calcareous compounds.

A good and suitable limestone having been employed, the resulting "quicklime," although very porous and very light, still retains much of the shape of the original limestone; that is to say, it is in lumps admitting of ready removal or carriage, such as the well known Staffordshire and Dorking lime.

Lime, from limestone, or "stone lime," should slake perfectly with water, and wholly crumble into hydrate of lime. This is a good and simple test of its "quickness." If, on the other hand, a hard "core," of a different colour to the surrounding lime, remain after "slaking," this proves the "lime-burning" insufficient, as the "core" is still undecomposed limestone; and if a fragment of the "core" be thrown into muriatic acid, diluted with an equal bulk of water, a plentiful effervescence will arise, due to the expulsion of carbonic acid.

Generally speaking, the "cores" being very hard, or stony, and different in colour to the lime, they are easily discovered, and separated during the slaking; but with "chalk lime" the "cores" are nearly as white as the original chalk, and actually consisting of it and being soft, are easily and frequently broken by the spades, shovels, or other tools employed by the workmen during the slaking, and thus become mixed with the real hydrate of lime.

If a lump of chalk lime be suspected as imperfectly burned, it will not perfectly crumble away when mixed with water, and its "core" will effervesce with the acid just named.

The only lime employed in some counties is obtained from shells, of which beautiful natural productions there are two classes, known as porcellaneous and mother of pearl shells. The hardening, *inorganic*, or calcareous portion of these classes is similar to the matter of limestone, viz., carbonate of lime, but the portion which confers strength and toughness upon porcellaneous shells, is an *organic* com-

pound termed *gelatin*, on account of its identity with ordinary *jelly*, and that of mother of pearl shells is an *organic* compound termed *albumen*, on account of its identity with the *white* of egg.

Carbon, oxygen, hydrogen, and nitrogen, are the ultimate elements of these proximate principles *gelatin* and *albumen*, and when heated or burned, these principles are decomposed, and resolved into several curious and complicated compounds, the chief of which are easily volatilized. Accordingly, if shells be heated to redness or calcined, their organic principles are decomposed, their inorganic principle or carbonate of lime is also decomposed to a certain extent, that is, the carbonic acid escapes, and quicklime remains.

Probably the use of "shell lime" cannot be strongly recommended, unless the shells have been well washed in fresh water, to free them from the saline matters of sea-water, and then wood should not be used as the fuel for their direct calcination, as its ashes yield alkaline matter, which, mingling with the lime, would render mortar made of it liable to remain damp; it has been proposed to calcine the washed shells in iron cylinders, properly set in a furnace, so that a current or draught of air may be created through them, and this leads to the mention of a very curious fact connected with the philosophy of "lime burning."

Although heat has been frequently cited as an agent for the decomposition of carbonate of lime, it is found that no thorough decomposition will ensue, if the aperture of the vessel employed for the calcination be closed against the access of air, the smoke and flame of the fuel, or the vapour of water.

If, for example, dry chalk be heated in a vessel so constructed as to prevent the access of these agents, very little carbonic acid will escape, the chalk will become hard and semi-transparent, like marble.

Palladio mentions that limestones, taken from a dry pit, are not so good for burning into lime as those from a moist and shady one. This fact is well known to our "lime-burners," and it appears, that the access of air, the smoke of the kiln, the watery vapour, all promote the escape, or wafting away, of the carbonic acid; or, in other words, when a limestone is dry, and heated in a covered vessel, that the small portion of carbonic acid evolved upon the first application of heat remains as a film, or stratum, preventing the evolution of any further portion.

As quicklime forms the basis of mortar and many cements used in building, a general statement concerning the chemistry of these useful materials may now be entered upon.

Perfectly burned lime should be selected, and slaked with water, the purer the better; dirty river water should not be used, as it would contaminate the lime with extraneous matters; and above all, sea-water should be avoided, as containing saline matters, which would interfere with the proper setting and drying of the mortar.

The French builders have three methods of slaking lime, which they denote by the terms, *extinction ordinaire*, *extinction par immersion*, and *extinction spontanée*. The first is the common plan of heaping up the lime, and adding water to this until it is all converted into hydrate. The second consists in placing the lime in baskets, plunging these into water, then quickly removing them, and emptying their contents into a pit, which, when filled, is closed by a trap-door; thus the water, vaporized by the heat of the chemical action, or more familiarly, the steam, is prevented from escaping, and compelled to abide in contact with the lime, thus insuring its perfect conversion into hydrate. The third method is to spread the lime in thin shallow layers upon the ground, that it may absorb water from the air, and thus slowly become hydrate without the evolution of heat. Of these methods, the first is the easiest, the second the best, and the third the worst, excepting for some kinds of hydraulic lime, for the lime, in addition to becoming hydrate, passes into the state of carbonate.

From the best experiments upon the subject, it appears that the proper sand for mixing with the lime to constitute mortar is "river sand," wholly *silicious*, and of a sharp clear grain. This sand may be immediately distinguished from *calcareous* sand by its not effervescing in dilute muriatic acid. Sea sand, unless most perfectly washed in fresh water,

* See p. 96, ante.